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A Neural Network Controller for Automated Composite Manufacturing

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At McDonnell Douglas Aerospace (MDA), an artificial neural network based control system has been developed and implemented to control laser heating for the fiber placement composite manufacturing process. This neurocontroller learns an approximate inverse model of the process on-line to provide performance that improves with experience and exceeds that of conventional feedback control techniques. When untrained, the control system behaves as a proportional plus integral (PI) controller. However after learning from experience, the neural network feedforward control module provides control signals that greatly improve temperature tracking performance. Faster convergence to new temperature set points and reduced temperature deviation due to changing feed rate have been demonstrated on the machine. A Cerebellar Model Articulation Controller (CMAC) network is used for inverse modeling because of its rapid learning performance. This control system is implemented in an IBM compatible 386 PC with an A/D board interface to the machine.

A Neural Network Controller for Automated Composite Manufacturing

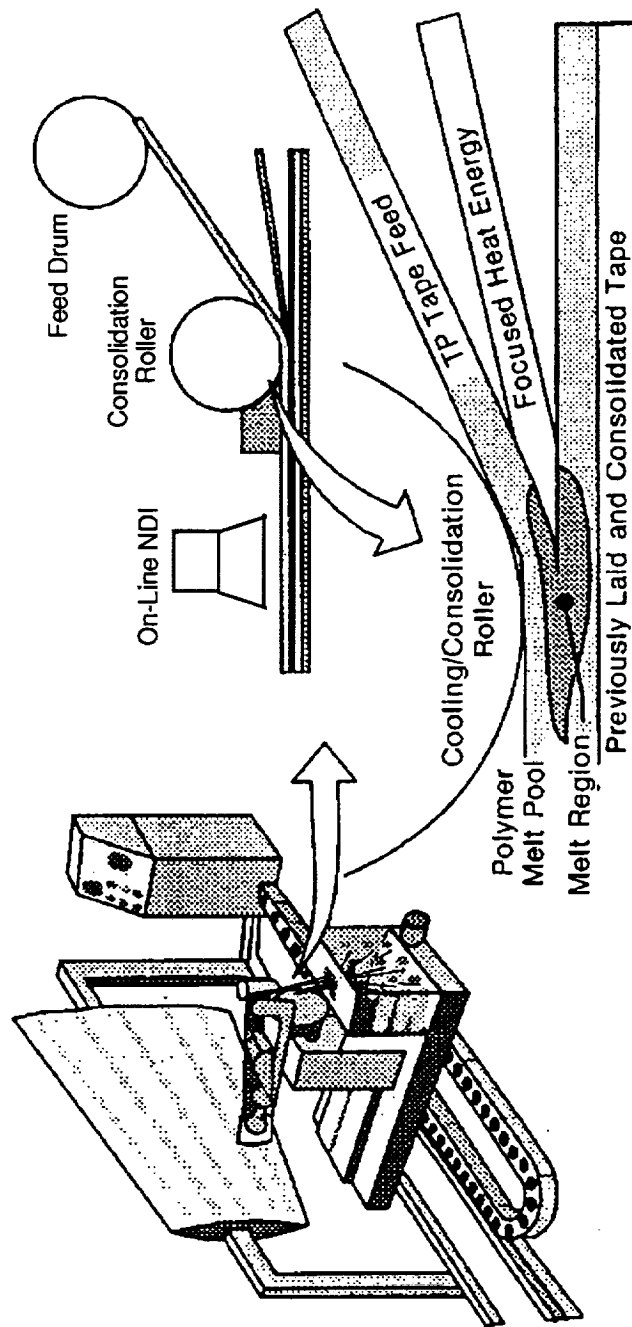
**JPL Neural Network Workshop
*A Decade of Neural Networks:
Practical Applications and Prospects***

May 11 - 13, 1994

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— MCDONNELL DOUGLAS AEROSPACE

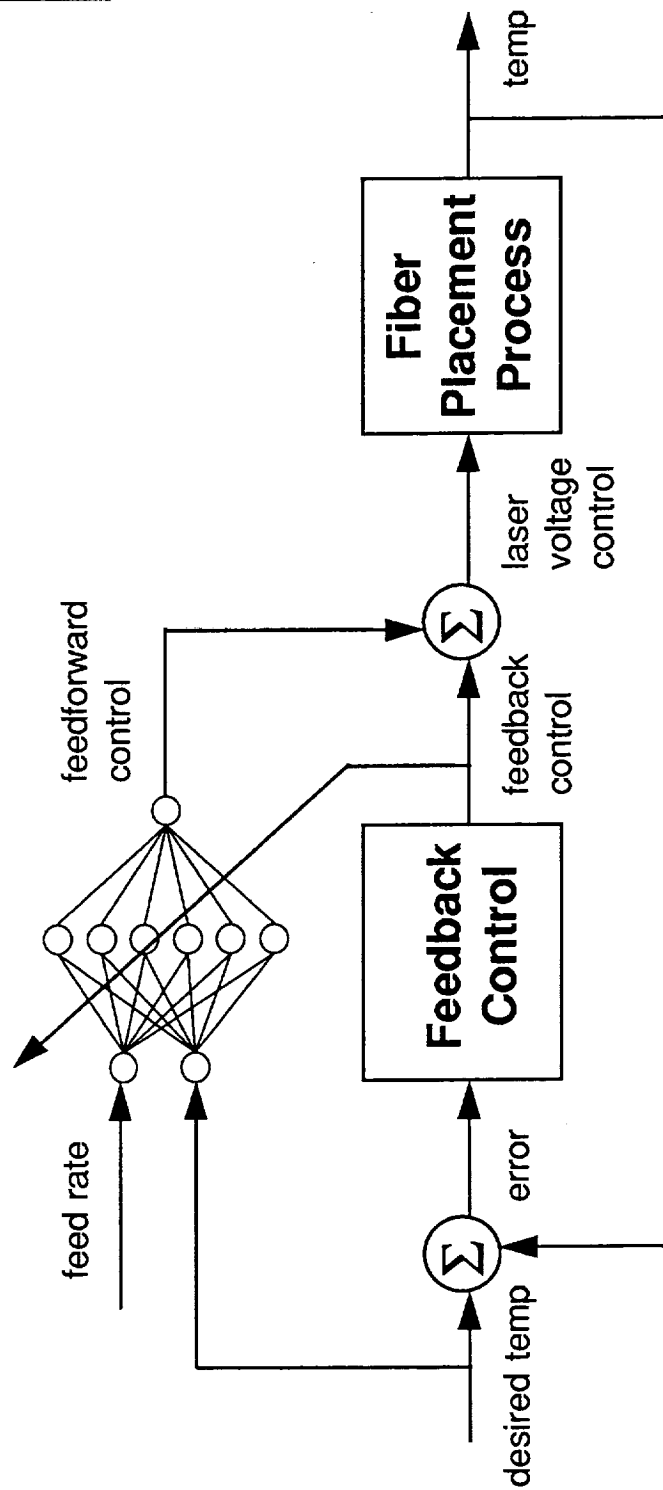
Thermoplastic Composite Fiber Placement Manufacturing Process



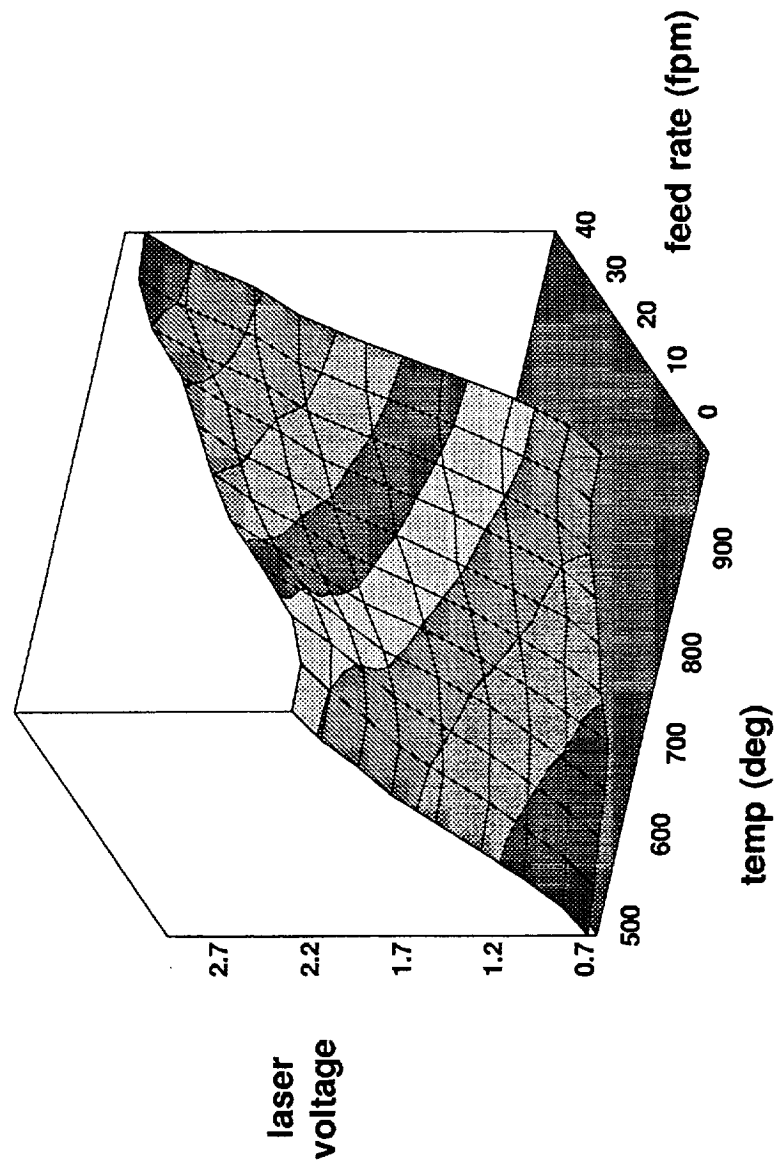
Features of Fiber Placement Process

- **Thermoplastic In-Situ Consolidation Eliminates:**
 - Manual Labor Intensive Material Lay-up
 - Vacuum Bag & Debulk
 - Autoclave
- **Potential for Every Layer Inspection**
 - Reduces Post-Process Inspection
 - Allows On-Line Repair
- **Accurate Process Control is Critical for Quality**
 - Complex Part Geometries Require Intelligent Control

On-Line Learning Neural Control for Fiber Placement Laser Heating



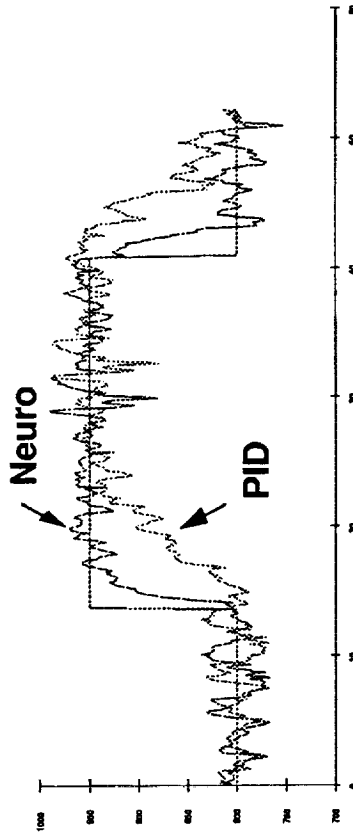
Control Law Learned by Neural Network



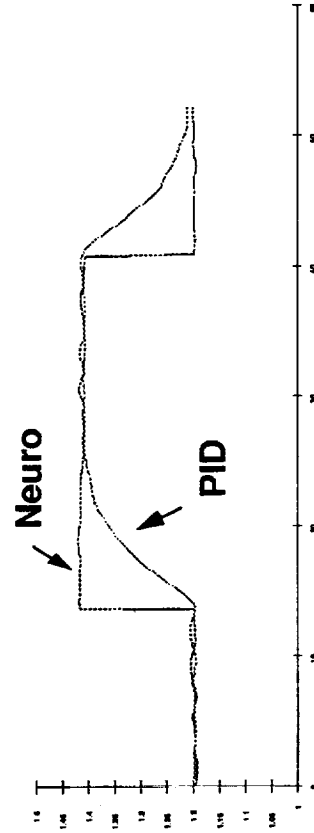
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Benefits of Neural Control over PID Control

**Faster Convergence
to New Temperature
Set Points**

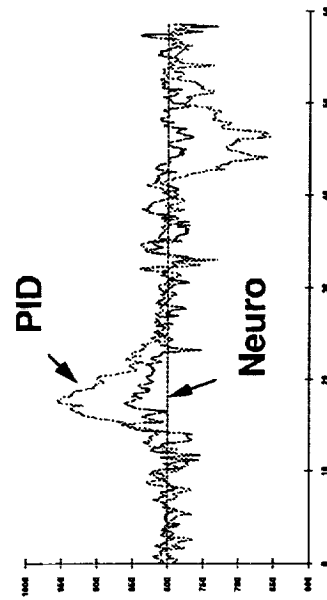


Control Voltage

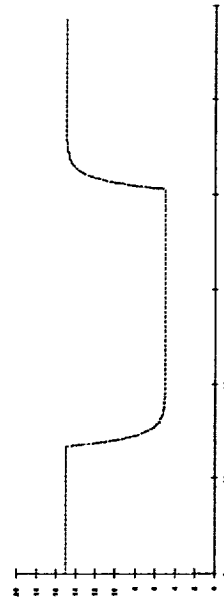


Benefits of Neural Control over PID Control

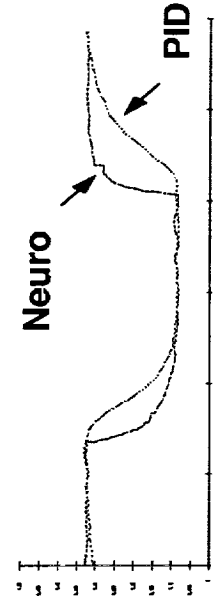
Reduced Temperature
Deviation due to
Feed Rate Changes



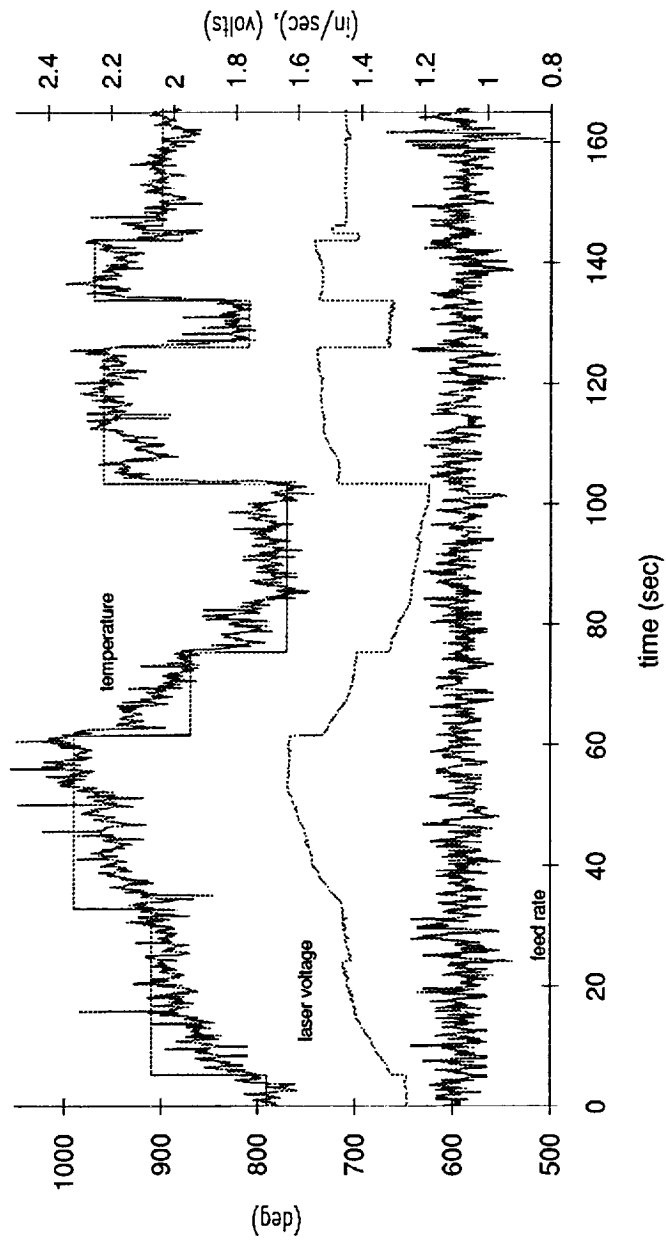
Feed Rate



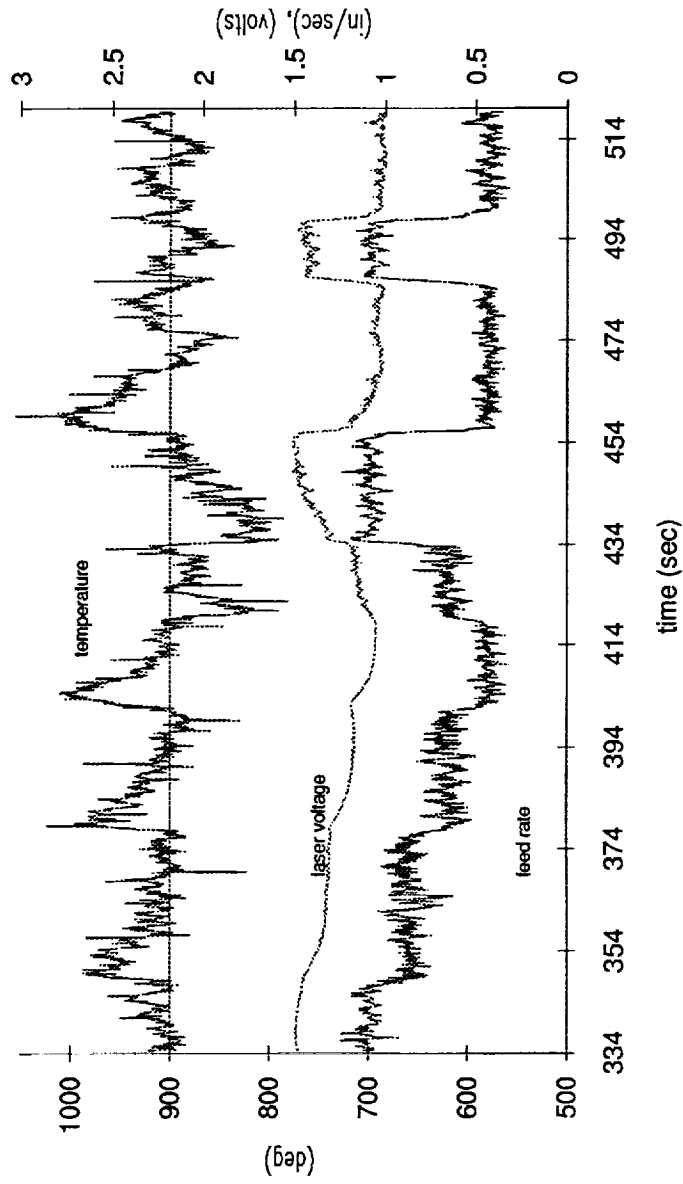
Control Voltage



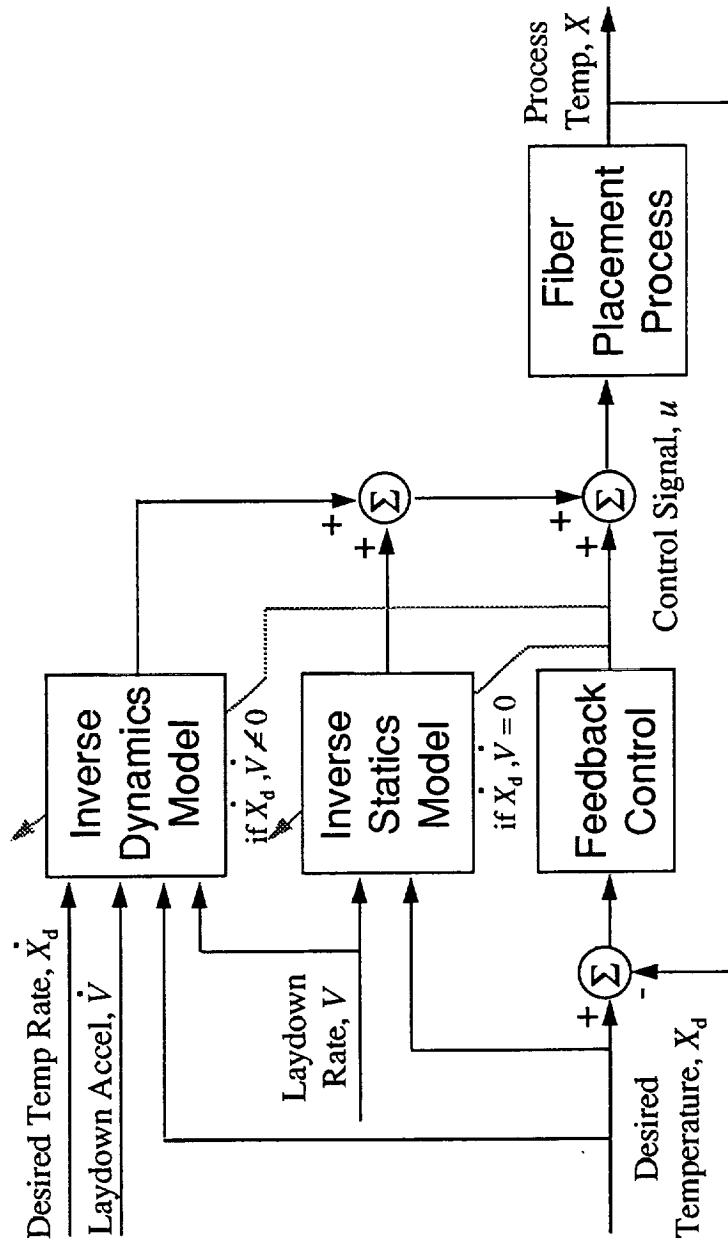
Neural Control Temperature Learning (Fiber Placement R&D Facility, 4/1/92)



Neural Control Feed Rate Learning (Fiber Placement R&D Facility, 4/1/92)



Architecture for Improved Dynamics Learning & Compensation



Future Work with Neural Networks

- **Enhance Fiber Placement Process Control**
 - Utilize Dynamics & Geometry Information
 - Implement On-Line Inspection Sensing
 - Integrate Material Process Modeling
- **Intelligent Control for High Speed Machining**
 - On-Line Learning for Precision Path Control
- **Smart Structure Applications**
 - Active Vibration Control for Flutter and Buffet